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Trends in educational differences in adolescent daily smoking across Europe, 2002–10

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Background: Across Europe, tobacco use is more prevalent among secondary school students attending vocational tracks compared with students attending academic tracks. The purpose of the present study is to describe trends in social inequality in daily smoking among adolescents between 2002 and 2010 by addressing both absolute social inequality (prevalence difference between vocational and academic tracks) and relative social inequality (prevalence ratio) in seven European countries. **Methods**: Analyses were based on data from 15-year-olds who participated in the *Health Behaviour in School-aged Children* study in 2002, 2006 and 2010 in Belgium, Croatia, France, Germany, Hungary, Italy and The Netherlands (total $N = 32\,867$). **Results**: Overall, daily smoking decreased between 2002 and 2010 in Belgium, France, Germany and The Netherlands, increased in Croatia and remained stable in Hungary and Italy. Considerable differences in daily smoking according to educational track existed in all countries. Absolute educational inequalities increased dramatically in Croatia and Italy, while relative inequalities showed a tendency to increase in all countries (significant in Belgium and The Netherlands). **Conclusions**: Conclusions on social inequality in adolescent smoking may appear differently when described by absolute and relative measures. Especially the large increase in absolute educational inequalities in daily smoking in Croatia and Italy are worrisome and warrant attention from the public health domain. The findings underline the need for appropriate smoking policies and interventions in vocational schools across Europe.

Introduction

Previous research in a wide variety of countries demonstrated that adults with a higher educational status are less likely to smoke than adults with a lower educational status.[1–7] While the graded relationship between educational level and smoking in adulthood has been the subject of intense research, far less is known about the magnitude and the pattern of educational differences in smoking among adolescents.[8–10] This is surprising as evidence of such an early life-course relationship would be a matter of concern. Moreover, the study of the development of educational inequalities in smoking during adolescence may provide a better understanding of the origins of socioeconomic differences in adult health and may identify possible pathways by which adult health inequalities are produced and reproduced.[11,12]

A few national studies have provided evidence of a relationship between educational track and adolescent tobacco use in Belgium,[13] Germany,[10] Slovakia[14] and Sweden.[15] Owing to different methods of data collection and analysis, international comparative studies have not been performed yet. This is a major gap in the literature, as it is unclear whether the findings of existing studies can be generalized to other European countries with different educational systems, health care provision and levels of welfare.

Moreover, recent studies of adult populations in Europe have demonstrated that the relation between educational status and smoking has changed, with smoking increasingly becoming a phenomenon typical for individuals of lower educational status.[6,16] It is unclear whether a similar development has occurred among adolescents. Recent studies showing the lower effectiveness of smoking prevention programs among adolescents of lower educational status[17] suggest that the educational gap in smoking may be widening among adolescents as well. A lack of social support,[16] lower confidence in the ability to quit smoking and higher nicotine dependence among the lower educated[18] may contribute to this widening gap.

The aims of the present study are (i) to identify educational differences in adolescent smoking in seven European countries and (ii) to test whether the relationship between educational track and adolescent smoking changed over time between 2002 and 2010 in these countries. Educational inequalities can be assessed by both absolute and relative measures. Relative measures (e.g. prevalence ratios, odds ratios, relative index of inequality) are appropriate when answering research questions on aetiology. Absolute measures (e.g. prevalence differences, slope index of inequality) may especially be useful for individual and clinical purposes and for decision-makers on public health issues.[19] In the present study, we present changes in social inequality in daily smoking by both absolute and relative measures of inequality.

Methods

The analysis was based on data from the Dutch, German, Belgian, Italian, French, Hungarian and Croatian *Health Behaviour in School-aged Children* (HBSC) study. Since 1983/84, cross-sectional surveys of 11-, 13- and 15-year-old adolescents have been carried out

every 4 years in a growing number of countries based on an internationally agreed protocol. A detailed description of the HBSC study can be found elsewhere.[20]

The seven countries included in this study were selected because they (i) had an educational system with different educational tracks and (ii) had registered the educational track of each respondent within their sample. The analyses of the present study are limited to the data collection waves from 2001/02, 2005/06 and 2009/10, as The Netherlands, Italy and Croatia only joined the study in 2001/02.

All samples were nationally representative, except for the Belgian sample (i.e. this sample was representative only for the Flemish region) and the German sample; owing to the differing school systems across the federal states in Germany, the present study could only include German data from the federal states of Northrhine Westphalia and Hesse in 2002 and 2006 and from three additional states (Bayern, Niedersachsen and Schleswig-Holstein; five states in total) in 2010. In 2010, Germany had a national survey for the first time. The three states were added to the sample in 2010 to have comparable sample sizes across survey years. All five states had a comparable school system. To control for differences in the composition of states in the different samples, all analyses on the German sample were controlled for federal state. Logistic regressions and analyses of variances (ANOVAs) revealed no differences between the initially included federal states and those that were added to the sample in 2010 with respect to daily smoking [$OR = 1.05$ (0.73–1.52)], gender [$OR = 1.04$ (0.83–1.30)], family affluence [$F(4, 1234) = 1.57$, $P = 0.18$] and adolescent academic achievement [$F(4, 1260) = 1.27$, $P = 0.28$].

Sample

All surveys used identical protocols considering target group, sampling and data collection. Samples were drawn by systematic cluster sampling in which the primary sampling units were either school classes or entire schools. The fieldwork took place between Autumn 2001/2005/2009 and Spring 2002/2006/2010. Only students whose parents did not object to their child's participation in the study and who volunteered to participate were included in the study. Participating countries and regions obtained institutional ethics approval. Response rates within classes ranged from 69% (Germany, 2010) to 96% (Hungary, 2010), with the main reasons for absence being illness and a lack of informed consent from parents.

In most countries, adolescents are not allocated to a specific educational track before the age of 15 years; therefore, the analysis for the present study was limited to 15-year-olds. In total, 32 867 students (15 874 male and 16 993 female) were included in the study. The characteristics of the different samples are presented in table 1.

Instrument and variables

Data were collected by means of a standardized questionnaire ensuring anonymity and confidentiality to the students, and administered in the classroom.

Daily tobacco smoking

Smoking status was defined on the basis of the question 'How often do you smoke tobacco at present?' Original answer categories (*never, less than weekly, weekly but not daily, daily*) were recoded into *no daily smoking* and *daily smoking*. As daily smoking is a crucial aspect of nicotine dependence,[21] daily smoking adolescents have an increased likelihood of smoking in the future and developing smoking-related health problems leading to premature deaths.[22]

Table 1 Basic characteristics of the samples

Country	Belgium			Croatia			France			Germany			Hungary			Italy			The Netherlands		
Survey year	2002	2006	2010	2002	2006	2010	2002	2006	2010	2002	2006	2010	2002	2006	2010	2002	2006	2010	2002	2006	2010
N	1830	1424	1102	1446	1601	2410	2614	2222	1740	1367	1892	1268	1310	1117	1641	1220	1255	1315	1273	1363	1457
Gender																					
% *Boys*	49.0	50.9	56.7	43.3	46.7	49.3	49.8	51.3	47.8	47.5	49.3	46.0	38.0	45.0	45.1	44.3	50.4	51.3	50.0	49.3	50.1
Mean age	15.5	15.5	15.5	15.4	15.6	15.5	15.1	15.6	15.5	15.7	15.4	15.4	15.5	15.5	15.5	15.9	15.8	15.5	15.5	15.4	15.4
Educational track																					
% Acad (high)	48.7	46.6	34.2	24.3	26.2	29.5	75.9	91.5	91.0	34.1	34.7	42.7	80.6	84.4	90.6	35.7	49.5	45.1	17.4	17.2	21.9
% Acad (medium)	–	–	–	–	–	–	–	–	–	14.3	18.8	9.4	–	–	–	–	–	–	23.8	20.4	20.2
% Acad (low)	33.5	31.6	47.5	45.2	41.1	48.6	–	–	–	26.4	26.3	28.2	–	–	–	42.3	32.4	40.5	34.8	33.7	36.4
% Vocational	17.8	21.8	18.2	30.5	32.6	22.0	24.1	8.5	9.0	25.2	20.3	19.7	19.4	15.6	9.4	22.0	18.2	14.4	24.0	28.7	21.6

Table 2 Overview of the classification of educational tracks per country

Country	Educational track	Classification
Belgium / Croatia / Italy	General secondary education / gymnasium / lyceum	Academic (high)
	Technical secondary education	Academic (low)
	Professional / vocational secondary education	Vocational
France / Hungary	Academic track	Academic
	Vocational track	Vocational
Germany	Gymnasium (grammar school)	Academic (high)
	Gesamtschule (comprehensive school)	Academic (medium)
	Realschule (intermediate school)	Academic (low)
	Hauptschule (general secondary school)	Vocational
The Netherlands	VWO (high academic education)	Academic (high)
	HAVO (medium academic education)	Academic (medium)
	VMBO-theoretical track (lower academic education)	Academic (low)
	VMBO-basic track (vocational training)	Vocational

VWO = Voorbereidend Wetenschappelijk Onderwijs; HAVO = Hoger Algemeen Voortgezet Onderwijs; VMBO = Voorbereidend Middelbaar BeroepsOnderwijs.

Educational track

As the participating countries in this study had different educational systems, we provide a short description of how the educational tracks in the different countries were categorized as either low, medium or high (see table 2). The choice for a specific educational track or school type generally depends on students' achievement in previous school years, but is also influenced by parents' socioeconomic status (especially its cultural and intellectual aspects[23] and access to social capital.[24]

Statistical analyses

Analyses were performed for each country separately, as it was difficult to directly compare the different national school systems. Overall prevalence rates of adolescent daily smoking and prevalence rates per educational track were presented for each year separately. Absolute time trends were estimated by calculating the difference in raw prevalence between 2002 and 2010. Relative time trends were estimated by means of a logistic regression model in Mplus (version 6.11).[25] Survey year was included in the model as two dummy variables, with 2002 being the reference category. The odds ratio of the year 2010 was presented as an indication of the trends. The analyses were controlled for differences across the years in the distribution of adolescents across educational tracks and for cluster effects (school as primary sampling unit). As no cluster variable was available for the German samples, we used $\alpha = 0.001$ to be more conservative for these samples.

Gender differences in overall trends were tested through interaction effects by means of a multiple group logistic regression analysis in each country, testing whether the trends in daily smoking were similar for boys and girls. If the model allowing gender differences had a better fit than the model in which trends were fixed to be equal across gender (based on the χ^2 difference test), results were presented separately for boys and girls. Otherwise, the overall trend analyses were controlled for gender.

Differences in daily smoking according to educational track were analysed for each survey year separately. Educational inequality was assessed by means of an absolute measure (i.e. by calculating the prevalence difference in daily smoking between adolescents in vocational and academic tracks) and a relative measure (i.e. by calculating the odds ratio indicating the relative likelihood that vocational students smoke daily compared with academic students). To examine gender differences, interaction effects were tested as described above.

To test whether the absolute differences in daily smoking according to educational track had changed over time, the change in prevalence difference scores between 2002 and 2010 was calculated. To test whether relative differences had increased between 2002 and 2010, a multiple group logistic regression analysis was performed with survey year as grouping variable. Two models were compared: a model in which differences in daily smoking according to educational track were allowed to increase across survey years and a model in which they were not. If the model allowing an increase in the differences according to educational track had a better fit (based on the χ^2 difference test), it was concluded that differences had increased.

Results

Overall prevalence and trends

Table 3 presents the prevalence rates of daily smoking among adolescents in the different educational tracks by country and survey year. In 2002, overall prevalence rates differed considerably across countries. Italian adolescents smoked least (15.8% daily smokers), whereas German adolescents smoked most (27.5% daily smokers). In 2010, German adolescents smoked least (10.2% daily smokers). Croatia, which scored among the lowest in 2002, had the highest prevalence in 2010 (19.7% daily smokers).

Absolute trend analyses revealed that adolescent daily smoking decreased especially strongly in Germany (−17.3%), but also in The Netherlands (−7.3%), Belgium (−7.2%) and France (−5.2%). In Croatia, adolescent daily smoking increased (+2.8%). Differences in prevalence between 2002 and 2010 in Hungary and Italy were small. The relative trend analyses confirmed this pattern. The results of the logistic regressions revealed that the prevalence of adolescent daily smoking between 2002 and 2010 decreased significantly in Germany, The Netherlands, Belgium and France, increased in Croatia and remained stable in Italy and Hungary.

Overall trends in daily smoking did not differ between boys and girls: $\Delta\chi^2(2) = 1.40$, $P = 0.50$ for Belgium; $\Delta\chi^2(2) = 1.12$, $P = 0.57$ for Croatia; $\Delta\chi^2(2) = 1.71$, $P = 0.42$ for France; $\Delta\chi^2(2) = 1.95$, $P = 0.38$ for Germany; $\Delta\chi^2(2) = 0.66$, $P = 0.74$ for Hungary; $\Delta\chi^2(2) = 0.59$, $P = 0.74$ for Italy and $\Delta\chi^2(2) = 2.72$, $P = 0.26$ for The Netherlands.

Differences in daily smoking according to educational track: prevalence and trends

In all countries, a pronounced gradient of educational track in daily smoking was observed. Absolute differences in daily smoking between students in vocational and academic tracks ranged from 5.1% (Italy, 2002) to 26.7% (Germany, 2002). Between 2002 and 2010, absolute differences dramatically increased in Croatia (+14.4%), Italy (+8.8%) and to a smaller extent in Hungary (+2.4%) and Belgium (+2.3%). They decreased in Germany (−7.9%) and The Netherlands (−5.0%) and fluctuated in France.

Table 3 Adolescent daily smoking according to educational track by country and survey year (2002–10)

Country	2002 (%)	2006 (%)	2010 (%)	Trend 2002–10	
				Absolute (%)[a]	Relative (OR, 95% CI)[b]
Belgium					
Total	18.1	11.9	10.9	−7.2	0.66 (0.59–0.74)
Educational track					
Academic (high)	9.8	5.4	3.2	−6.6	0.58 (0.45–0.73)
Academic (low)	24.2	11.6	10.9	−13.3	0.59 (0.49–0.71)
Vocational	29.8	26.3	25.5	−4.3	0.89 (0.71–1.10)
Absolute prevalence difference (%) (Voc–Acad)[a]	20.0	20.9	22.3	+2.3	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	2.16 (1.79–2.61)	2.65 (2.05–3.42)	3.29 (2.47–4.38)*		
Croatia					
Total	16.9	20.0	19.7	+2.8	1.17 (1.02–1.35)
Educational track					
Academic (high)	10.3	9.8	9.6	−0.7	0.97 (0.68–1.39)
Academic (low)	18.1	16.7	19.5	+1.4	1.06 (0.88–1.28)
Vocational	20.0	32.3	33.7	+13.7	1.52 (1.22–1.89)
Absolute prevalence difference (%) (Voc–Acad)[a]	9.7	22.5	24.1	+14.4	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	1.53 (1.07–2.20)	2.39 (1.88–3.05)	2.51 (2.01–3.12)		
France					
Total	19.8	14.3	14.6	−5.2	0.89 (0.79–0.99)
Educational track					
Academic	16.3	13.6	13.4	−2.9	0.88 (0.78–1.00)
Vocational	31.0	22.3	29.0	−2.0	0.85 (0.61–1.20)
Absolute prevalence difference (%) (Voc–Acad)[a]	14.7	8.7	15.6	+0.9	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	1.63 (1.38–1.93)	1.44 (1.08–1.91)	1.73 (1.28–2.34)		
Germany					
Total	27.5	14.9	10.2	−17.3	0.54 (0.47–0.61)
Educational track					
Academic (high)	14.5	7.7	3.0	−11.5	0.39 (0.30–0.52)
Academic (medium)	29.5	18.4	13.4	−16.1	0.49 (0.33–0.71)
Academic (low)	25.6	15.2	12.0	−13.6	0.60 (0.48–0.76)
Vocational	41.2	24.9	21.8	−19.4	0.55 (43–0.72)
Absolute prevalence difference (%) (Voc–Acad)[a]	26.7	17.2	18.8	−7.9	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	2.38 (1.95–2.90)	2.13 (1.75–2.59)	3.00 (2.27–3.95)		
Hungary					
Total	19.0	17.5	18.3	−0.7	1.04 (0.87–1.24)
Educational track					
Academic	15.5	15.0	16.4	+0.9	1.03 (0.84–1.26)
Vocational	33.1	31.0	36.4	+3.3	1.11 (0.84–1.45)
Absolute prevalence difference (%) (Voc–Acad)[a]	17.6	16.0	20.0	+2.4	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	1.78 (1.49–2.13)	1.71 (1.28–2.28)	1.87 (1.44–2.43)		
Italy					
Total	15.8	14.0	15.8	+0.0	1.03 (0.90–1.19)
Educational track					
Academic (high)	13.6	11.6	11.5	−2.1	0.90 (0.72–1.12)
Academic (low)	16.1	12.6	17.2	+1.1	1.04 (0.84–1.30)
Vocational	18.7	22.8	25.4	+6.7	1.26 (0.91–1.74)
Absolute prevalence difference (%) (Voc–Acad)[a]	5.1	11.2	13.9	+8.8	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	1.24 (0.94–1.65)	1.57 (1.17–2.10)	1.71 (1.29–2.27)		
The Netherlands					
Total	19.2	14.1	11.9	−7.3	0.74 (0.64–0.85)
Educational track					
Academic (high)	8.6	3.4	1.9	−6.7	0.49 (0.34–0.70)
Academic (medium)	11.1	7.6	7.1	−4.0	0.79 (0.58–1.09)
Academic (low)	18.4	14.6	14.0	−4.4	0.84 (0.66–1.07)
Vocational	34.3	24.6	22.6	−11.7	0.70 (0.55–.89)
Absolute prevalence difference (%) (Voc–Acad)[a]	25.7	21.2	20.7	−5.0	
Relative prevalence difference (OR, 95% CI) (Voc–Acad)[b]	2.69 (2.08–3.47)	3.10 (2.10–4.59)	3.83 (2.71–5.44)*		

a: Absolute differences refer to the differences in raw percentages (2010–02 for trends and vocational–academic for educational differences).

b: Relative differences (odds ratios; ORs) were calculated by means of logistic regression models adjusted for gender and cluster effects. To calculate the relative educational differences, educational track was entered as (a) dummy variable(s) in the model. The highest academic track was the reference category. The *OR* of the vocational track is presented. *OR*s gradually increased as tracks became more oriented towards vocational training (data not presented). CI = confidence interval.

*The trend over time in educational differences is statistically significant ($P < 0.05$).

Relative differences, as expressed by odds ratios, ranged from 1.44 (France, 2006) to 3.83 (The Netherlands, 2010). Only in Italy in 2002, relative differences were not significant. Relative differences had a tendency to increase in all countries. This increase was significant in Belgium [$\Delta\chi^2(4) = 7.72$, $P = 0.05$] and The Netherlands [$(\Delta\chi^2(6) = 11.70$, $P = 0.03$], but not in Croatia [$\Delta\chi^2(4) = 5.82$, $P = 0.11$], France [$\Delta\chi^2(2) = 0.88$, $P = 0.32$], Germany [$\Delta\chi^2(6) = 9.29$, $P = 0.08$], Hungary [$\Delta\chi^2(2) = 0.17$, $P = 0.46$] and Italy [$\Delta\chi^2(4) = 4.72$, $P = 0.16$].

Also with respect to the association between educational track and daily smoking, no gender differences were found: $\Delta\chi^2(2) = 1.24$, $P = 0.54$ for Belgium; $\Delta\chi^2(2) = 3.29$, $P = 0.19$ for Croatia; $\Delta\chi^2(1) = 0.48$, $P = 0.49$ for France; $\Delta\chi^2(3) = 4.61$, $P = 0.20$ for Germany; $\Delta\chi^2(1) = 2.25$, $P = 0.13$ for Hungary; $\Delta\chi^2(2) = 5.50$, $P = 0.06$ for Italy and $\Delta\chi^2(3) = 1.43$, $P = 0.70$ for The Netherlands.

Discussion

To our best knowledge, this is the first study to examine trends in educational differences in adolescent smoking in a cross-national perspective. The results show that in all countries, vocational secondary school students are more likely to be daily smokers compared with academic students. Absolute educational differences in daily smoking were especially large (>20%) in Belgium and The Netherlands. Between 2002 and 2010, they increased dramatically in Croatia and Italy. Relative differences were largest in Belgium, Germany and The Netherlands. They showed a tendency to increase in all countries; this increase was significant in Belgium and The Netherlands.

The cross-national consistent association between educational track and adolescent smoking confirms findings from previous national studies.[10,13–15] While the strong association between school type and daily smoking might also be the effect of selection processes resulting from differential home environments and reflect different social norms and parental modelling behaviours related to smoking, the specific school environments could also have independent effects on smoking. With increasing age, the influence of family background on adolescents decreases, while the influence of peers increases.[9,26,27] Educational track may thus largely represent effects of differential peer clusters and school-related factors such as achievement motivation and school performance. Previous research has suggested a process in which peer clusters with a higher likelihood of performance problems create a 'school-alienated' peer climate that might be considered a risk factor for health-compromising behaviours such as smoking.[10]

Both the absolute increase in educational differences in daily smoking in Croatia and Italy and the relative increase in educational differences in Belgium and The Netherlands are consistent with Rogers' theory of diffusion of innovation[28] and Lopez' model of the smoking epidemic.[29] According to these models, the smoking epidemic in industrialized countries has evolved in four stages.[28,29] In the first stage, smoking pervades the higher educated groups (innovators). During the second stage, smoking spreads to the rest of the population, including the lower educated groups (laggards). The third stage is characterized by the start of cessation in the higher educated groups, male dominance and a rise in female smoking. Finally, in the fourth stage, smoking declines among the higher educated groups, but remains high among lower educated groups. By the end of the 20th century, most Northern and Western European countries (Belgium, France, Germany, The Netherlands) were classified as stage 4, while Southern and Eastern European countries (Croatia, Hungary, Italy) were classified as stage 3.[5,22,28,29] The overall decreasing trends identified in Western European countries, the stable or increasing trends in Southern and Eastern European countries, the absolute increase in smoking among especially vocational students in Croatia, Hungary and Italy and the increasing relative educational differences in Belgium and The Netherlands identified in the present study are in line with this classification.

Our study extends previous research on adult populations in Europe, which identified increasing (relative) educational inequalities in smoking behaviours in the end of the 20th century.[6] This increase among adults was explained by public health initiatives being most effective in stabilizing or cutting down tobacco consumption among the higher educated. Although our findings confirm a similar trend among adolescents in Belgium and The Netherlands, it should be acknowledged that these trends are likely to be a mathematical consequence of the general decrease in smoking prevalence and the low prevalence rates among academic students in these countries. More concerning than these relative increases are the increases in daily smoking among vocational students in Croatia, Hungary and Italy.

To our best knowledge, only three previous studies examined trends in educational differences in smoking among European adolescents. A German study found that between 1994 and 2002, the impact of educational track on smoking remained virtually unchanged in adolescent boys and girls.[10] A Finnish study found that absolute differences in smoking according to school performance increased among adolescents in Finland between 1977 and 2007.[30] Finally, a Danish study found that social inequality (according to parental occupational status) in adolescent smoking (both absolute and relative) fluctuated between 1991 and 2006.[19] The present study, based on more recent data and a larger number of contrasted countries, provides a comprehensive overview of the development over time in educational differences in adolescent smoking across Europe.

Study strengths and limitations

The HBSC study presents an outstanding opportunity to analyse cross-national trends in tobacco smoking and inequalities in tobacco smoking among young people in industrialized countries. The strengths of this study include the use of a large cross-national dataset and a standardized protocol with respect to the data collection adhered to in all countries. Limitations include the use of self-report of tobacco use. In general, self-reported smoking prevalence has been considered a valid indicator of the actual smoking status,[31,32] especially in epidemiological studies. However, tobacco smoking is a normatively loaded topic and there may be an uneven distribution of social desirability effects among different socioeconomic and cultural groups, which could lead to an overestimation of educational differences in tobacco use. To underline the importance of honest responses, before filling in questionnaires, students were assured of the anonymity of the study and that neither parents nor teachers would find out about their individual answers.[33]

A second limitation is that our data were cross-sectional. Therefore, we cannot make any causal inferences. For example, based on the findings of this study, we cannot draw any firm conclusions on the relative importance of school climate and the effect of selection processes in recruitment of students.

Finally, although we controlled the trend analyses for differences across the years in the distribution of students across educational tracks, it is important to note that in six of these seven countries, the proportion of pupils in vocational tracks decreased from 2002 to 2010. This may reflect the dynamics of a vertical social mobility, which leaves adolescents from families with few resources in vocational tracks, i.e. vocational tracks may be qualitatively different in 2002 and 2010. Future research may examine to what extent this process influenced the trends in educational inequality in smoking.

Implications

Conclusions on social inequality in adolescent smoking may appear differently when described by absolute and relative measures. The present findings underline the need for appropriate smoking policies

and interventions in vocational schools across Europe. While there is an overall trend towards a decrease in adolescent smoking in Western Europe, the stabilizing or increasing general trends in adolescent smoking in Croatia, Hungary and Italy and the accompanying increase in absolute educational inequalities in smoking in these countries are worrisome and warrant attention.

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Conflicts of interest: None declared.

Key points

- This article is the first to investigate cross-national trends in educational differences in tobacco smoking among adolescents in Europe.
- Between 2002 and 2010, a steep overall decrease in smoking prevalence was found among adolescents in Belgium, France, Germany and The Netherlands, while an increasing trend was found in Croatia; stable trends were observed in Italy and Hungary.
- Large differences in adolescent daily smoking according to educational track were found in all the countries included in the study.
- Absolute educational differences in smoking increased considerably in Croatia and Italy and slightly in Belgium and Hungary. In all countries, a tendency towards increasing relative educational inequalities was observed (significant in Belgium and The Netherlands).
- The strong association between educational track and daily smoking points to the importance of health promotion and health education programs conducted in the school setting to reduce social health inequalities.

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Innovations in medical care and mortality trends from four circulatory diseases between 1970 and 2005

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Background: Governments have identified innovation in pharmaceuticals and medical technology as a priority for health policy. Although the contribution of medical care to health has been studied extensively in clinical settings, much less is known about its contribution to population health. We examine how innovations in the management of four circulatory disorders have influenced trends in cause-specific mortality at the population level. **Methods:** Based on literature reviews, we selected six medical innovations with proven effectiveness against hypertension, ischaemic heart disease, heart failure and cerebrovascular disease. We combined data on the timing of these innovations and cause-specific mortality trends (1970–2005) from seven European countries. We sought to identify associations between the introduction of innovations and favourable changes in mortality, using Joinpoint-models based on linear spline regression. **Results:** For both ischaemic heart disease and cerebrovascular disease, the timing of medical innovations was associated with improved mortality in four out of five countries and five out of seven countries, respectively, depending on the innovation. This suggests that innovation has impacted positively on mortality at the population level. For hypertension and heart failure, such associations could not be identified. **Conclusion:** Although improvements in cause-specific mortality coincide with the introduction of some innovations, this is not invariably true. This is likely to reflect the incremental effects of many interventions, the time taken for them to be adopted fully and the presence of contemporaneous changes in disease incidence. Research on the impact of medical innovations on population health is limited by unreliable data on their introduction.

Introduction

It is now widely accepted that improvements in health care are among the factors that have contributed to the reductions in mortality observed in all industrialized countries over recent decades. However, while this view can draw on a wealth of research showing that specific interventions improve the outcomes of various diseases, with at least some of the studies measuring reduction in mortality, it has been rather more difficult to attribute the decline in deaths from particular conditions to specific interventions. A few studies have found associations between the timing of certain interventions and reductions in mortality at the level of populations, but such analyses are few.[1–3] Yet, the extent to which innovations in health care have actually contributed to population health gain is a non-trivial but important question that is still not answered adequately.[4,5] Several studies have tried to quantify the impact of health care on the decline in cardiovascular mortality after 1970 assuming that there are factors attributable to medical care (cholesterol, hypertension, other treatments) and external factors (smoking, alcohol and nutrition). Yet, while there is considerable disagreement on the magnitude of the impact, varying between 25,[6] 40,[7–9] 71[10] and 75%,[11] there is a consensus that the contribution of medical care is far from trivial.

This article presents a new methodology to assess empirically the effect of selected medical innovations on four cardiovascular causes of death, which are among the most common in the European Union.

Hypertension

Although this condition is often considered as a risk factor for other circulatory diseases, it is also an important cause of death in its own right. In the last few decades, several treatments have been introduced, such as beta-blockers, angiotensin converting enzyme (ACE) inhibitors, diuretics and calcium antagonists.[12] However, while all have been shown to be effective in lowering blood pressure in clinical trials, there is a lack of direct evidence linking their use to a decrease in mortality from hypertension at a